UTILIZING FORMAL INNOVATION MODELS TO SUPPORT AND GUIDE INDUSTRY INNOVATION PROJECTS

H van Zyl[1] , N.D. du Preez[2], and C. Schutte[3]

Department of Industrial Engineering
University of Stellenbosch, South Africa
[1]hivanzyl@gmail.com, [2]nddp@sun.ac.za, [3]corne@sun.ac.za

ABSTRACT

The high failure rate of innovation projects indicates that many companies are not getting the full benefit from their innovation projects [1], [2]. A research project was carried out during 2005 that explored and compared the existing formal models for supporting innovation, in order to address the identified problem. It proposed guidelines for improving and refining innovation projects. A case study that focused on the front-end of product innovation in the wine industry and the applicability of the formal W-model [3] to innovation activities was used to evaluate how formal innovation models can indeed effectively support industry innovation projects. The innovation life cycle was used to categorize a number of innovation frameworks for product, process, and enterprise innovation. Further research should focus on extending the case study to other industries, such as the automotive sector.

OPSOMMING

Die groot aantal onsuksesvolle innovasie projekte dui daarop dat maatskappye nie die volle voordele uit hul innovasie projekte kry nie [1], [2]. ’n Navorsingsprojek is gedurende 2005 uitgevoer om bestaande formele innovasie modelle te evalueer, ondersoek, en vergelyk, met die doel om bogenoemde probleem aan te spreek en riglyne voor te stel wat innovasie sal bevorder en verfyn. ’n Gevallestudie, wat fokus op produkinnovasie in die wyn-industrie, is uitgevoer om die toepaslikheid en effektiewe ondersteuning van die formele W-model [3] op spesifieke innovasie aktiwiteite te evalueer. Die innovasie-lewensiklus is ook gebruik om ’n aantal innovasie-raamwerke te kategoriseer in afdelings vir produk-, onderneming- en proses-innovasie. Toekomstige navorsing behoort te fokus op ’n uitbreiding van die gevallestudie na ander industrië soos die motorindustrie.

[1] The author is enrolled for the MSc Engineering at the Department of Industrial Engineering, University of Stellenbosch

1. INTRODUCTION: THE CURRENT GLOBAL MARKET AND INNOVATION

According to Peter Drucker [4]: *"…business has only two basic functions – marketing and innovation..."*. Only recently have companies fully realized the extensive impact of innovation on the sustained success of an organisation. Companies are now being forced by the fast-changing business environment of global competitiveness, extremely fast technology developments, and demanding customer requirements, to concentrate on innovation in order to survive [5]. Irrespective of the main trigger for global innovation awareness, the reality is that, more than ever before, recurrent innovation has become a necessity for any business that wants to survive and grow.

In 2004 Deloitte and Touche [6] conducted a research study on innovation, focusing not only on the necessity but also on the difficulty of innovation. The results of this study, based on research from 650 leading manufacturers worldwide, indicated that launching new products and services is the most important driver for growth. It also indicated that new product revenue was expected to increase to 35% of sales by 2006, compared to 21% in 1998. Customer demands are changing and competitor offerings are improving at such a rapid pace that products, which represent more than 70% of current sales, will be outdated in five years' time. This study also reported that the majority of manufacturers do not have reliable systems for bringing new products and services to the market, and that 50% to 70% of all new product introductions fail.

2. WHY DO SO MANY INNOVATION PROJECTS FAIL?

Innovation has a multifaceted life cycle that results in the development and commercialisation of products, services, and processes. The life cycle consists of invention, feasibility, implementation, operation, and disposal phases (as depicted in Figure 1). This life cycle impacts a company as a whole, and not just the Research and Development department. Within a company, innovation projects vary widely from one project to another, but they often are interrelated.

Rothberg [7] has stated that a product has two key dimensions: technology and markets. *Technology* involves knowledge, which enables the product to be produced economically. *Markets* include to whom and how the product will be sold, enabling profitable distribution. Thus, a synthesis of value offerings that aligns customer needs with technological possibilities lies at the heart of innovation.

Many competitors have the same leading technology and high-class processes, which force them to compete on the grounds of the best product rather than the lowest price. Although price-cutting will always be an objective of any company, it is no longer a guaranteed differentiator. If a company does not produce the right product at the right time, the price of the product will not have a significant impact.

According to a study by Stevens and Burley [8] that combined data from previous studies on innovation success rates, it takes about 3,000 raw ideas to produce one

truly new and commercially successful product. Walker stated [9]: *"Creativity on its own is only a beginning. Human beings are relentlessly creative. Having ideas is relatively easy – having good ideas is slightly more difficult – but the real challenge lies in carrying ideas through into some practical result."*

Therefore, the key to a company's survival and growth is a continuous flow of new and improved products. The challenge does not lie in generating ideas alone, but rather in mastering the whole complex innovation process, which also entails the pursuit of choosing the correct ideas and successfully growing these ideas into products.

With the constant pressure to innovate faster and faster, to try to beat competitors and put innovations on the market as soon as possible, companies are often compelled to take important decisions under uncertain conditions, and thus again to risk failure when engaging in innovation activities for technical or commercial reasons. *"There is powerful evidence that once a company's core business has matured, the pursuit of new platforms for growth entails daunting risk. Roughly one company in ten is able to sustain the kind of growth that translates into an above-average increase in shareholder returns for more than a few years*." [10]

3. HOW CAN INNOVATION BE BETTER SUPPORTED TO ENSURE MORE SUCCESSFUL INNOVATIONS?

Companies often ignore the crucial phases of developing strategies and processes for new product development. Such companies will often find themselves choosing projects that are not aligned with their capabilities or available resources, and will, consequently, suffer lengthy development periods and high failure rates. Schilling [11] suggests that the process of innovation can be better supported: *"While innovation is popularly depicted as a freewheeling process that is unconstrained by rules and plans, study after study has revealed that successful innovators have clearly defined innovation strategies and management processes."*

In agreement with Schilling, Schon [7] states that innovation is destructive to a company's stable state and that risk is involved, but that it is possible to keep the risks of innovation within boundaries – by processes of justification, decision, and optimisation. According to Rothberg [7]: *"…there is a great deal of wasted time and effort in new product development. What are required are good strategic planning, proper management controls, and healthy organisational attitudes."* Therefore, improving a company's innovation success rate requires a well-crafted strategy, aligning projects with a company's resources, objectives, and core competencies.

Uncertainty accompanying innovation may be reduced using a structured model, as this not only guides innovators, but also helps them to learn from their experience and to capture knowledge. Utilizing a structured approach will make it easier to align multi-disciplinary teams with the same goal and to create mutual understanding and common terminology, as innovation projects usually involve various people from different backgrounds and expertise. Additionally, performing innovation tasks

within a structure helps participants to keep track of project progress, to assign tasks, and to integrate different efforts.

The goal of innovation activities must be to create and maintain a rate of advancement greater than that of the competition. It is important to recognize innovation as a process, and not as magic, coincidence, or pure invention. Patterson [12] confirms this: *Translating a market opportunity into a new product requires perhaps 15 percent invention. The remaining 85 percent of the work involves previously learned processes that are often undocumented and undisciplined.* Thus innovation entails more processes than invention. Innovation activities and tasks outcomes can be anticipated, controlled and supported. The utilization of a structured innovation approach should result in more successful innovations.

4. FORMAL INNOVATION STRUCTURES

Innovation frameworks establish the important relationships between innovation inputs, strategy, operations, market needs, and final outputs. The function of a framework is to guide the processes of collecting and analysing data in order to determine the abovementioned relationships and desired results. Several formal innovation models exist, and each was developed within a certain environment, for some specified purpose and with various levels of detail and scope. Therefore, some models will be better suited than others for a specific innovation project. To be able to select the best-suited innovation model for a project, it is necessary to compare the existing innovation models with a common life cycle. The Innovation Landscape in Figure 1 was compiled for this purpose.

Every innovation project also has a beginning, a purpose, and an end. As indicated by the five phases of the Innovation Landscape, every innovation project goes through the same phases as it progress from its invention phase through to its disposal phase. These life-cycle phases describe the progression of an innovation project from beginning to end, but they may also be used to describe the necessary steps in the development of a future project. The full life cycle consists of five phases:

1. Invention – The generating of ideas
2. Feasibility – The specification, design, functional analysis, and concepts
3. Implementation – The detailed design and manifestation of the concepts
4. Operation – The production and related maintenance activities
5. Disposal – The execution of the system

These five phases of the Innovation Landscape are closely related to life cycle phases used by researchers such as Campbell [13] and Williams *et al* [14] to compare innovation models.

For the sake of completeness, this Innovation Landscape includes the three types of formal innovation model:

1. Enterprise innovation architectures. (These models have been produced to organise all the enterprise integration knowledge required to identify the need for change, and to carry out that change successfully within enterprises.)
2. Product innovation models. (In this case 'product' refers to both tangible manufactured products and intangible service products.)
3. General innovation models. (These models can be customized and applied to either enterprise- or product-innovation projects.)

In Figure 1 below, the Innovation Landscape is populated with various formal innovation models. The black blocks represent enterprise innovation models, the white blocks represent product innovation models, and the grey blocks represent the general innovation models that can be applied to both enterprise- and product-innovation projects.

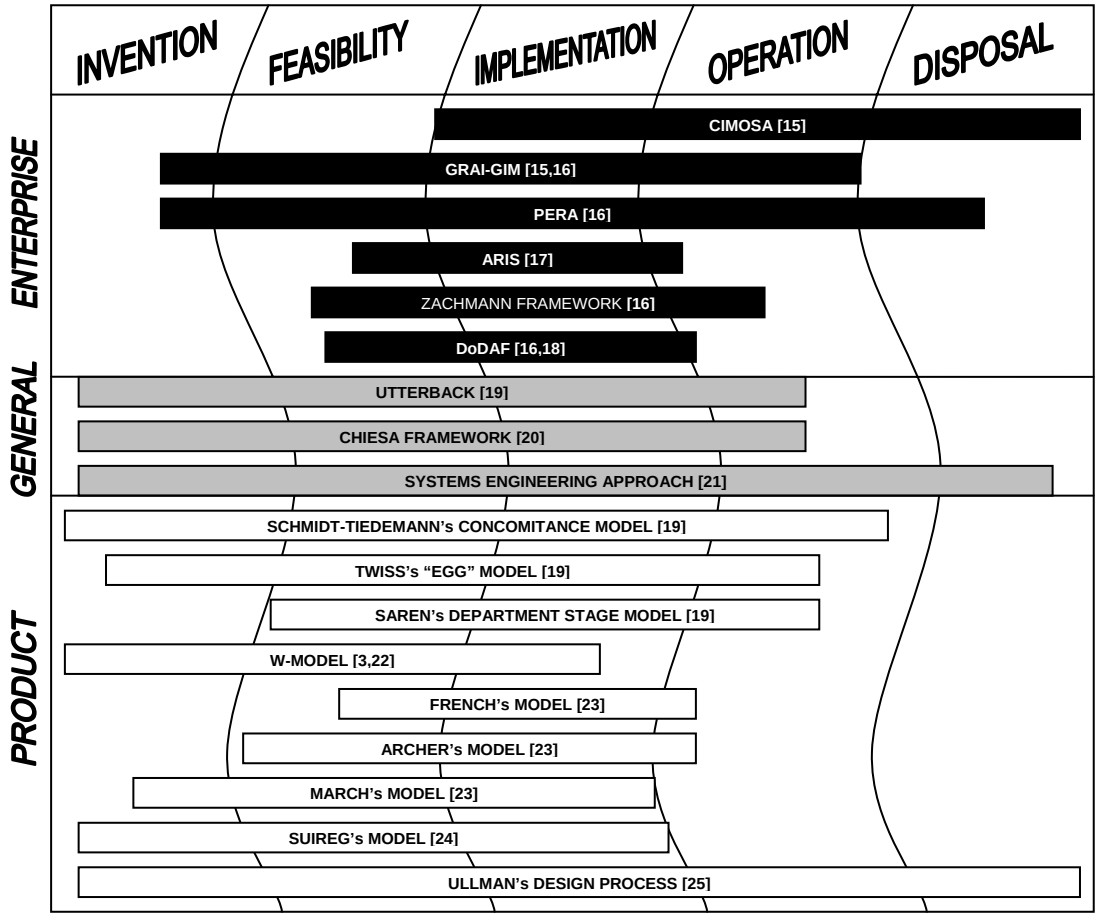


Figure 1: The Innovation Landscape

Figure 1 was compiled by researching the various models' sources, functions, levels of detail, scopes, and industry applications, and then mapping the area that each model supports and focuses on, on to the common Innovation Landscape. The Innovation Landscape provides a user with comparative information on the various models, and on the innovation life cycle coverage of each model. Innovation models can be compared, and a user can then select the appropriate model to support a specific innovation project.

5. SELECTING AN APPROPRIATE FORMAL INNOVATION MODEL FOR AN INNOVATION PROJECT

A case study was undertaken to explore the selection and evaluation of an innovation model. The selected formal model was also compared with actual (informal) innovation project steps. This case study focused on a product innovation in the South African wine industry. In the South African winelands, innovation is reshaping tradition and making its mark on the wine world. This reshaping was triggered when South Africa re-entered the international markets in 1994, and has been accelerated by recent customer demand for 'New World' wines. Wood and Kaplan [26] note that in order to survive in the highly competitive national and international markets, role-players from right across the value chain – marketers, distributors, and representative bodies of winemakers, growers, labourers, and research institutions – are all spending time and money on creating 'innovation-driven' and 'market-directed' products and processes.

This case study focuses on an innovation by Collotype Paarl Labels – which is situated in Paarl, and specializes in self-adhesive labelling for the wine industry – called Wine Find^{TM}.

Collotype's Wine Find^{TM} is a peel-off label on the wine bottle. It forms part of the label, but it can easily be removed as it is perforated, and the small peel-off label does not have an adhesive reverse side. If a consumer enjoys a specific wine, the peel-off label allows the consumer to take with them the small label containing information about the wine, the winery, and how it can be obtained, for later reference when buying or ordering wine. The information usually includes the wine cultivars, the harvest year, the winery's name and address, and its contact and sales details. Collotype created the Wine Find^{TM} for marketing and promotional purposes. As the sales information is stuck to the wine bottle, the Wine Find^{TM} transforms a wine bottle label from a purely informative instrument into a marketing and sales tool.

Collotype Paarl Labels does not use a formal innovation model to support its innovation activities. This case study examined the informal process of innovation that the company followed for the Wine Find^{TM} development. A formal innovation model was selected from the Innovation Landscape, and the two approaches were compared. The aim of the case study was not only to demonstrate how to select an appropriate formal innovation model for a specific innovation application, but also to establish the applicability, level of support, and advantages of utilising a formal innovation model.

The innovation process followed by Collotype Labels – an informal and responsive approach, stemming from the combined previous experience of the team members – can be divided into seven main steps. It also contains feedback loops for continuous improvements and refinements. The seven steps are as follow:

1. *Identify the market opportunity* – A request came from a customer to have a removable reminder of the wine details.

2. *Brainstorming* – During the brainstorming sessions many packaging ideas within industries other than the wine industry were explored. Cost effectiveness was an important issue. The conclusion of the brainstorming was that a perforated/peel-off label was the best concept.

3. *Agreement on exclusivity and commercialisation support with initial customer* – In order to start the development of and experimentation with concepts, the initial customer was contacted to assist with the innovation activities. The initial customer carried a share of costs of the trial and error processes and, in return, received six months' market exclusivity on the final product.

4. *Prototyping* – Several prototypes were developed (see figure 2), evaluated, and then improved. Market research was carried out concurrently.

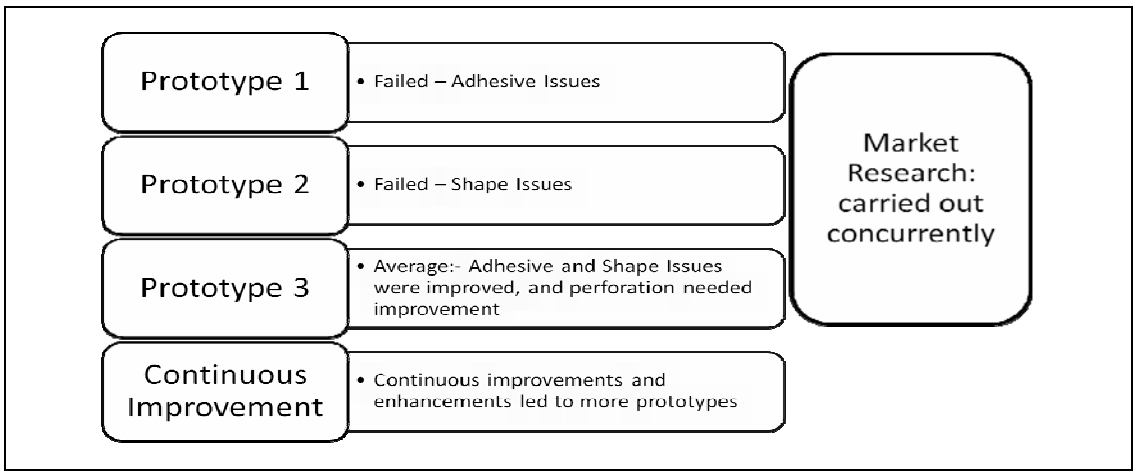


Figure 2: Collotype Prototyping

5. *Market research* – The development team determined that it was technically possible to produce the product concepts with existing equipment. The next logical step was to conduct market research in order to get closer to the customer, with the goal of matching the available technology with customer requirements/ preferences.

6. *Implementation of research feedback* – Feedback from the market contact resulted in improvements in the appearance, position, and information of the peel-off label, and also other product- and service-innovation ideas.

7. *Standardization of operational procedures* – Lastly, standard operational procedures were created. These included technical, design, and production manuals, accompanied by measurements and transfer-time framework details. Products are not released to the market if they do not measure up to the standards (cost, quality, speed etc.) set out in the operating procedures.

In order to select a formal innovation model for the development of the WineFind™ label, one needs to look at the product innovation models that focus on the lifecycle phases of invention, feasibility and implementation. From the populated Innovation Landscape below (see Figure 3), it is clear that the W-Model is the innovation model that best addresses this identified area. In Figure 3 the focus area of the case study is highlighted in grey and the W-Model is circled, showing its position relative to the whole Innovation Landscape.

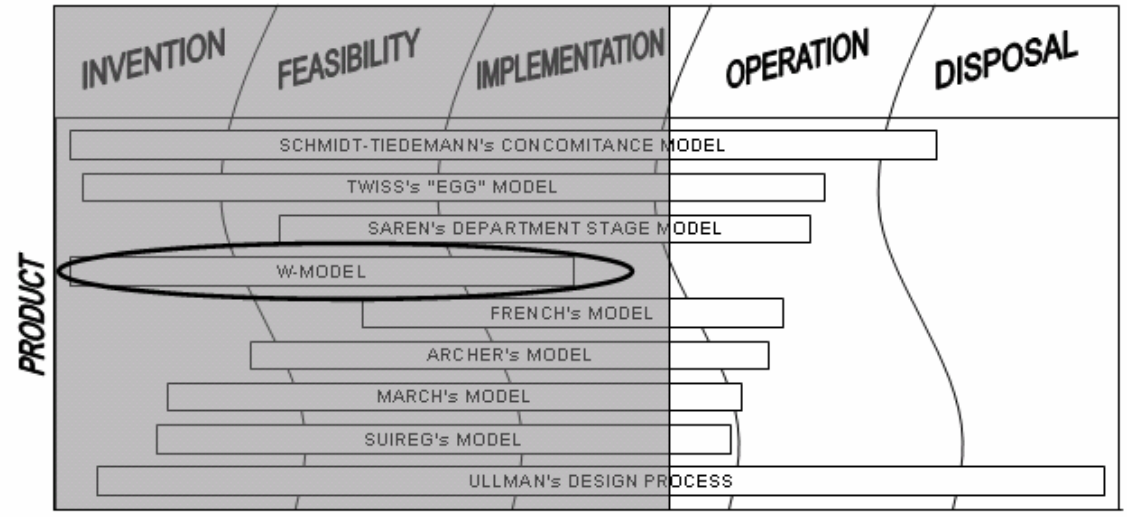


Figure 3: The focus area of the case study within the broader Innovation landscape

The W-Model was developed by the Fraunhofer IPT for technical product innovations. This model describes the process of product innovation in the following seven steps (see Figure 4) [22]:

Defining objectives – the innovation planning is adjusted to the overall business strategies and capabilities.

Analysing the future – innovation opportunities are derived from the business capabilities and future trends.

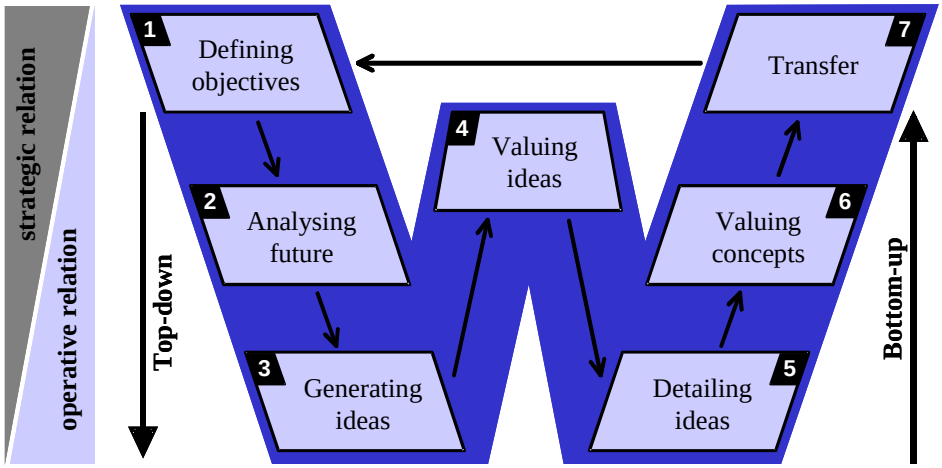
Generating ideas – innovation opportunities are transformed into specific second order ideas.

Valuing ideas – with very little detailing yet done, product ideas are evaluated according to the company, market, and technology potential.

Detailing ideas – further market and technology information, in order to develop the selected product concepts, is acquired.

Valuing concepts – taking the information acquired in the previous step into account, product concepts are compared and evaluated.

Transfer – the results of the preceding steps are incorporated into the Innovation Roadmap (IRM), and selected innovation projects are plotted on a timescale for transfer planning.



Source: Baessler [3]

Figure 4: The W-Model

In order to guide the user and enhance the effectiveness of this model, tools and techniques are associated with each of the seven steps, with the goal of ensuring the systematic development of the necessary information.

The two triangles on the left side in Figure 4 indicate that the W-Model takes both the strategic and operational issues into consideration throughout the innovation process, thus ensuring that the innovation projects are aligned with the strategic goals and that they fall within the operational capabilities range.

If we look at the life-cycle coverage of the W-model in more detail, it is evident that it provides very good guidance from the invention phase to the innovation phase (to some degree) (see Table 1). It also provides the innovator with activities associated with the mentioned phases and the necessary 'toolkits'.

6. INDUSTRY VS RESEARCH: CAN INFORMAL INNOVATION MODELS EFFECTIVELY SUPPORT ACTUAL INDUSTRY INNOVATION PROJECTS?

The research project objective was to establish whether the careful selection and deployment of a formal innovation model would provide better support of innovation projects and facilitate quicker and more successful innovation. It is thus necessary to evaluate if the existing formal innovation models are indeed beneficial to real-life problems. When matching the informal and formal approaches to innovation with one another, it is evident that, although companies might see theoretical models as too complicated and not in touch with reality, most areas in the two approaches actually do correspond. These similarities are shown below in Figure 5, which

illustrates which phases of the W-Model cover the same activities as the seven steps used by Collotype Labels.

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	Yes	The activities of this life cycle phase are covered by the W-Model's steps: 1. defining objectives; 2. analysing future; and 3. generating ideas.
2. Feasibility	Yes	Ideas are evaluated and tested for feasibility during step 4, valuing ideas. After detailing the second-generation ideas, the concepts are further analysed and evaluated in step 6, valuing concepts.
3. Innovation	Some	Some innovation activities are performed during the detailing of second-generation ideas, but the output of the W-Model is an Innovation Roadmap, which plots innovation projects on a timeline. The further development of each innovation project needs to be performed per innovation concept and according to the suggested timeline.
4. Operation	No	Although production capabilities and marketing aspects are analysed and captured during the execution of the W-Model steps, this approach does not support the production and maintenance phase, but provides some valuable guidelines for operational planning.
5. Disposal	No	The model does not give attention to the execution of an innovation product.

Table 1: The life-cycle coverage of the W-Model

The solid lines indicate the steps of the informal model that are fully covered by the associated W-Model step, while the dotted lines indicate the steps of the informal model that are partially covered by the associated W-Model step. As can be seen from Figure 5, only the last steps of the two models are completely different, and their functions are also not contained in any other step of the corresponding model.

The seventh step of Collotype's informal approach entails planning and setting out procedures, boundaries, and measurements of the production of the innovation product, whereas the final step of the W-Model involves classifying the innovation concept into to-be-revised, immediate, and longer-term innovation project categories and the plotting of the projects on a timeline. In order for an innovator to be able to make strategic decisions on the timeline of innovation projects, operational information must have already been generated, studied, and captured in the preceding steps. Thus, it can be said that the last step of Collotype's seven steps is completely

focused on the operational issues of the innovation project, contrasting with the final step of the W-Model, which relates to strategic relations.

The informal approach is a much leaner one than the W-Model as it is shaped for this specific application. However, because it was developed from prior experience, the risk exists that the innovator will not know what aspects are not properly considered until those features create problems. Should this happen, then this informal innovation approach would become more re-active in nature.

The advantages and positive impacts of formal innovation models on a company's innovation activities have been discussed before, and it is clear from the mapping of the two innovation approaches against each other that the W-Model could indeed have been applied to the Wine Find™ innovation project.

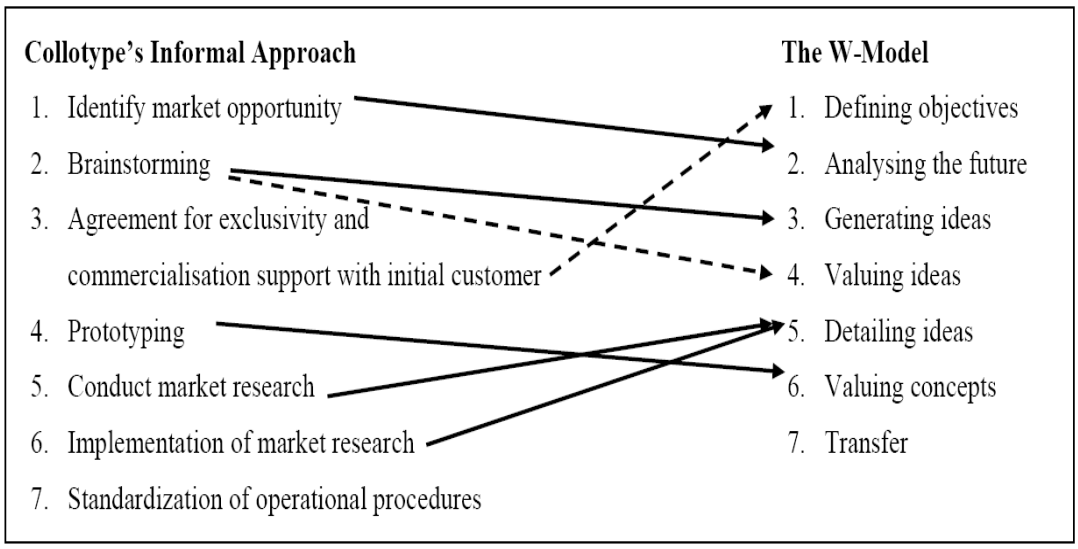


Figure 5: Comparing Collotype's seven steps to the phases of the W-Model

More specifically, if the W-Model had been used instead of an informal innovation process, it would have provided the development team with the following advantages:

- Extensive tools and techniques, e.g. creativity techniques the portfolio analysis the TRIZ method [3], the QDF method [3], the value benefit analysis, etc., for performing each sub-step.
- Clear descriptions of the necessary inputs and outputs are provided in each of the seven phases, thereby ensuring that the innovator does not neglect essential tasks – and also ensuring that tasks are performed at the best time in the innovation development in order to obtain the greatest value and to try to eliminate re-work.
- A step-by-step procedure for choosing and developing the best innovation product, as the W-Model is a *pro-active* approach to product innovation, specifically designed to assist an innovator.
- Useful information (such as market research on customer needs, outcomes of technical feasibility studies, testing of various materials' strength, contact

information of people/companies with valuable professional contributions, etc.) would have been generated and captured, both for the current innovation project and for comparable future projects, when the innovator progressed through the seven phases of the W-Model.

- A common 'language', a unified goal, and processes to obtain the goal would have been created, as the W-Model is a *formal* innovation guide when used by a group of people participating in an innovation project.
- It would have been clear how and where specific information was generated and captured, and what decisions were made. Using the W-Model would have resulted in improved knowledge sharing between teams.

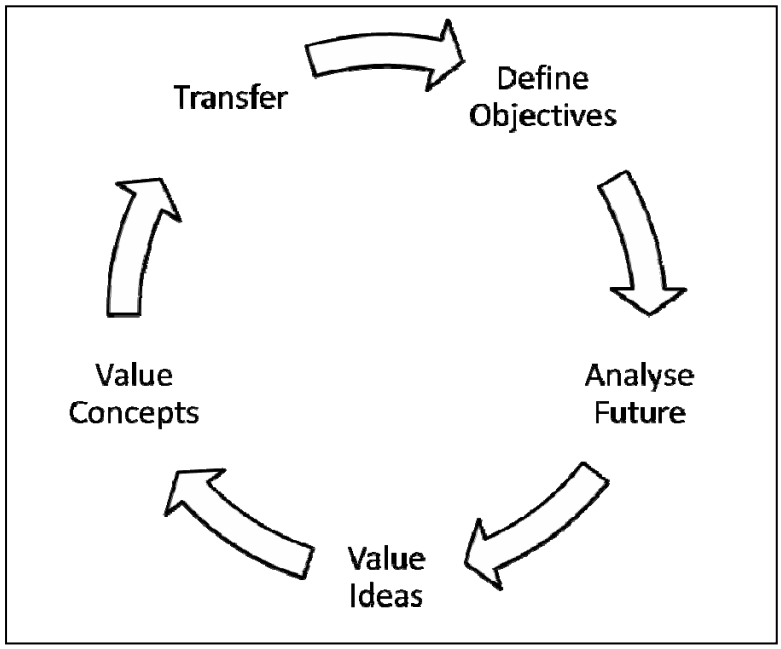


Figure 6: The closed loop image of the strategically related phases of the W-Model

7. TAILORING THE FORMAL W-MODEL TO SUIT COLLOTYPE LABELS' INNOVATION PROJECTS

In order to customize the W-model for future innovation projects such as the innovation development of the WineFind^{TM}, a gap analysis was performed to address the following question: If the W-Model had been applied to the Wine Find^{TM} innovation project, what shortcomings of the W-Model (if any) could have been identified? When comparing the phases of the W-Model with the stages of the informal approach, a difference can be observed. The W-Model is more strategically focused than the informal approach (see Figure 5). It should not be considered a disadvantage that a lot of emphasis is put on the strategic, but the shortcoming is rather that the W-Model does *not include the operational related output* that the informal approach has.

As illustrated in Figure 6, the stages of the W-Model form a continuous circle that brings about recurring innovation activities on a strategic level. The final output of the W-Model is an Innovation Roadmap, which identifies future innovations and immediate innovations with a lot of potential for success, as well as innovations that should be investigated in more detail or at a later stage. The W-Model thus builds in strategic planning for immediate and future innovation projects, and creates a further input for the W-Model (projects to be revised or investigated further).

In contrast, the stages of the W-Model with a 'relatively high' to 'high' operational relation do not form a closed circle but a linear progression, as can be seen in Figure 7.

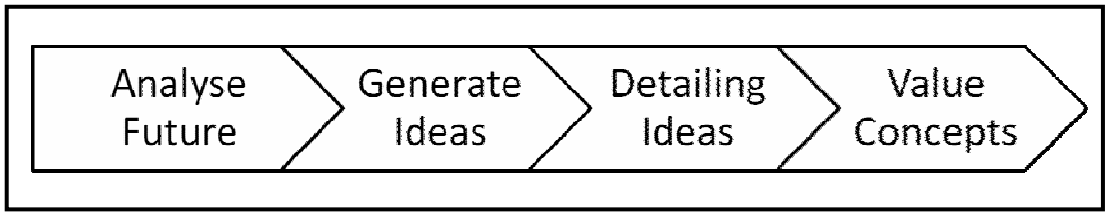


Figure 7: The linear representation of the operationally related phases of the W-Model

As the first phase of the operationally related phases is also strategically related, this linear representation of the operationally related phases of the W-Model therefore has an input; but this results in a dead end, as operationally related information is not transferred from the implementation life cycle phase to the production life cycle phase.

Thus, a limitation of the W-Model that was identified when applied to the Collotype Labels case study is that the W-Model does not communicate operational detail to the next innovation life cycle phase, namely production. At each step in the W-Model, information that allows the innovator to make decisions about the continued development of a specific innovation idea is being generated. However, this is not done in a way or format that can be shared and passed on to the operationally related business functions that will need to implement the operational requirements for the production of the chosen innovation projects. The proposed solution is thus to transform the current static form, containing valuable operationally related information, into a guiding structure where the information can be organised and contextualised, using a common language and indicating the relationships and logical flow between the information elements. This would enhance the teamwork, collaborative efforts, and transfer between the different departments and also between the various Collotype Labels locations internationally. The new suggested roadmap structure is set out in Figure 8 below.

This Operationally Related Innovation Roadmap consists of three stages and two decision gates. Predefined sub-steps guide the innovators through the three phases, ensuring that all of the considerations required for a successful innovation are addressed at the appropriate point in the development. Decision gates are points in the Operationally Related Innovation Roadmap where formal decisions must be

made to continue, terminate, suspend, or reprocess the innovation project. The information supplied at each sub-step is measured against the pre-defined success criteria of the decision gate.

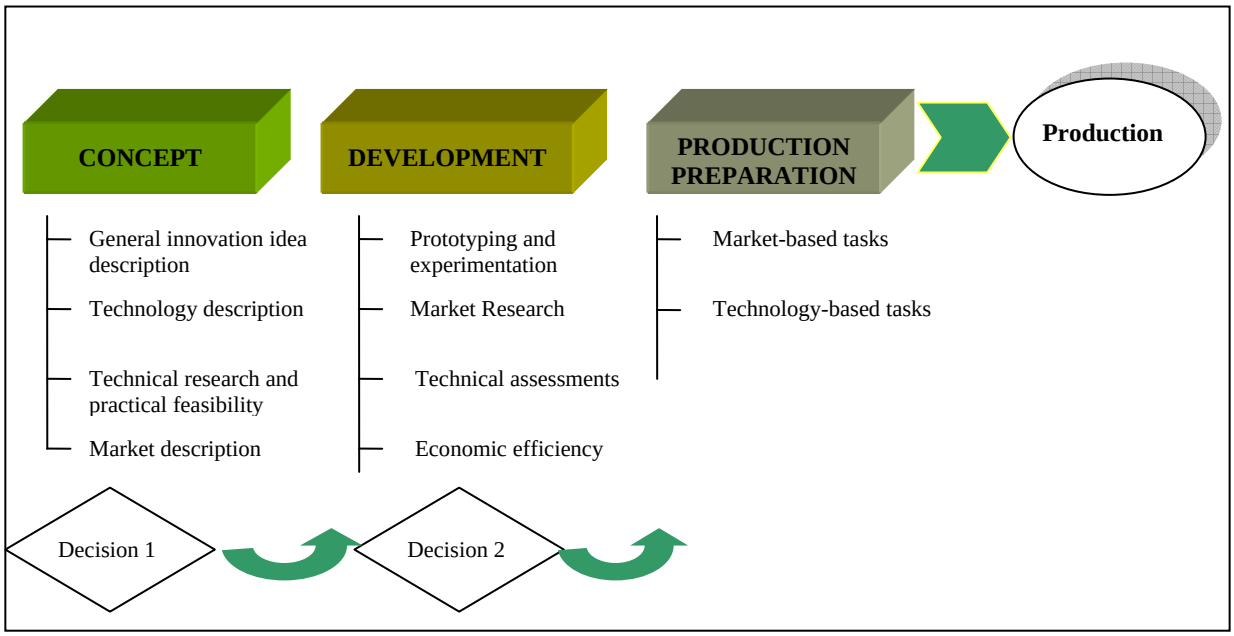


Figure 8: The proposed Operationally Related Innovation Roadmap

The next table, Table 2, shows the correspondence between the information generated during the execution of the W-Model steps (utilizing various established tools and techniques [22], [3]), and the capturing of information in the newly proposed structure.

The Operationally Related Innovation Roadmap is just an adaptation and different application of information that is already being generated during the execution of the seven W-Model steps. It does not, therefore, require the creation of additional information and analyses, but rather structures the existing information in such a way that it guides the implementation of an innovation product.

Value is thus added to the generated information through the use of this new approach to capturing the information in an easily accessible and useful format. This structure allows the team involved with the production of the final innovation ideas easily to understand the thinking behind the idea, the development of the concept, the assessment of the concept, and, most importantly, the details of the operational tasks for the production of the innovation product. The Operationally Related Innovation Roadmap is a substantial enhancement of the W-Model for use by Collotype Labels for future projects, as it successfully addresses the shortcoming identified in the case study, and it creates an environment that encourages innovation.

Operationally Related Innovation Roadmap sub-steps	W-Model sub-steps	W-Model tools and techniques
General innovation idea description	Analysing future Generating ideas	TRIZ method Innovation potential matrix Morphologic box
Technology description	Valuing ideas Detailing ideas	Portfolio analysis TRIZ method Primary and secondary market research Criteria model
Technical research and practical feasibility	Valuing ideas Detailing ideas	QFD method Primary and secondary market research Pairwise comparison
Market description	Valuing ideas Detailing ideas	Portfolio analysis TRIZ method Primary and secondary market research Criteria model
Prototyping and experimentation	Detailing ideas Valuing concepts	QFD method Kano model Selection algorithm
Market research	Detailing ideas Valuing concepts	Primary and secondary market research Kano model
Technical assessment	Valuing concepts	Value benefit analysis Technology calendar
Economic efficiency	Valuing concepts	Criteria model Economic evaluation methods
Market-related tasks	Detailing ideas Valuing concepts	Conjoint analysis Portfolio analysis
Technology-related tasks	Valuing ideas Detailing ideas Valuing concepts	Technical capabilities analysis QFD method Technology calendar

Table 2: The relationship between the Operationally Related Innovation roadmap and the W-Model information composition

8. CONCLUSION

Many companies hold that formal models do not represent actual innovation conditions, and that they are too detailed for the fast-moving business world. Through the case-study, this belief was proven to be far from the truth. Existing formal innovation models have been developed through extensive experience and

studies, and are therefore a suitable basis for a company's innovation activities. In order to reap optimal benefits, the model should be chosen correctly and transformed into a company-specific innovation model.

In conclusion, a company needs to keep moving forward by being recurrently innovative, but at the same time minimizing the risks and doubts involved through the employment of a reliable, supportive innovation model.

9. REFERENCES

[1] **Parker, A.,** 2000**.** *What will the future bring?* Design for Excellence Conference.

[2] **The Boston Consulting Group (BCG) Inc.**, 2005. *BCG senior Management Survey 2005*, Boston, USA. URL: http://www.bcg.com **(**accessed on 19 April 2005)

[3] **Baessler, E., Breuer, T. & Grawatsch, M.**, 2002. *Combining the scenario technique with QFD and TRIZ to a product innovation methodology*, Fraunhofer Institute of Production Technology IPT, Aachen, Germany. URL: http://www.triz-journal.com (accessed on 26 April 2005)

[4] **Drucker, P.,** 1985. *Innovation and entrepreneurship: Practice and principles*, Heinemann, London.

[5] **Commonwealth of Australia**, 2001. *Technology planning for business competitiveness, a guide to developing technology roadmaps*, Copyright in ABS Data resides with the Commonwealth of Australia, pp 2.

[6] **Deloitte & Touche South Africa,** 2004. *Mastering the innovation paradox.* URL: http://www.deloitte.com/globalbenchmarking (accessed on 6 January 2005)

[7] **Rothberg, R.,** 1981. *Corporate strategy and product innovation*: *The importance of innovation*, The Free Press, USA.

[8] **Stevens, G. & Burley, J.,** 1997. '3000 raw ideas equal 1 commercial success!', *Research technology management*, 40(3), pp 6-27.

[9] **Henry, J. & Walker, D.,** 1991. *Managing innovation*, SAGE Publications Ltd., London.

[10] **Christensen, C.,** 1997. *The innovator's dilemma: When new technologies cause great firms to fail*, Harvard Business School Press, Boston, USA.

[11] **Schilling, M.,** 2005. *Strategic management of technological innovation*, McGraw-Hill/Irwin, New York University, USA.

[12] **Patterson, M.,** 1993. *Accelerating innovation: Improving the process of product development*, Van Nostrand Reinhold, USA.

[13] **Campbell, R**., 2004. *Architecting and innovating*. URL: http**:**//cipd.mit.edu (accessed on 12 July 2005)

[14] **Williams, T., Li, H., Bernus, P., Uppington, G. & Nemes, L**., 1998. *The life-cycle of an enterprise*. URL: http://www.mit.edu (accessed on 12 July 2005)

[15] **Nazzal, D.,** 2004. Reference architecture for enterprise engineering: CIMOSA, GRAI/GIM, PERA, In: *Presentation for The School of Industrial and Systems Engineering at the Georgia Institute of Technology (ISyE)*. URL: www2.isye.gatech.edu (accessed on 3 October 2005)

[16] **Bernus, P., Nemes, L. & Schmidt, G.,** 2003. *Handbook of enterprise architectures (International handbooks on information systems)*, Springer, USA.
[17] **ARIS Framework Concept,** 2005. *IDS Scheer – ARIS Platform*. URL: www.ids-scheer.com (accessed on 3 October 2005)
[18] **Schekkerman, J.,** 2004. *A Comparative survey of enterprise architecture frameworks*, Institute for Enterprise Architecture Developments/Capgemini. URL: www.enterprise-architecture.info (accessed on 3 October 2005)
[19] **Forrest, J**., 1991. Models of the process of technological innovation, *Technology Analysis & Strategic Management*, 3(4), pp 439.
[20] **Verhaeghe, A. & Kifr, R.,** 2002. Managing innovation in a knowledge intensive technology organisation, *R&D Management*, 32(5), pp 409.
[21] **Blanchard, B. & Fabrycky, W.,** 2006. *Systems engineering and analysis*, Prentice Hall, USA, 4th edition.
[22] **Eversheim, W.,** 2003. *Innovationsmanagement für technische Produkte*, Springer, Berlin.
[23] **Cross, N.,** 1994. *Engineering design methods, strategies for product design*, John Wiley and Sons, UK, 2nd edition.
[24] **Suireg, A.,** 1981. *Methodology of mechanical systems design*, Heurista, Zurich.
[25] **Ullman, D.,** 2003. *The mechanical design process*, McGraw-Hill, USA, 3rd edition.
[26] **Wood, E. & Kaplan, D.,** 2004. Marketing, innovation and performance in the South African wine industry, in: *Proceedings of the 2nd Global Conference of Innovation Systems and Development: Emerging opportunities and Challenges*, October 2004. China: Beijing.